THE STORMS OF SOUTH AFRICA.

By A. G. Howard.

[Read 4th May, 1887.]

INTRODUCTION.

The subject which I am going to deal with to-night, is one which has exercised the minds of meteorologists ever since meteorology has been in existence ; that is to account for the various phenomena relative to storms.

Ever since the invention of the Barometer, theories have been advanced on the subject of its oscillations.

First, it was thought that the wind was the cause and not the effect. But no reason was shewn why the wind blowing from one direction should cause the mercury to rise, and from another direction cause it to fall.

A great light was thrown upon the question when simultaneous observations were plotted down, and lines of equal pressure, called isobars, drawn. It was then discovered that these isobars invariably resolved themselves into a form approaching to that of a circle.

The next discovery made was that the wind always blew round the circle with the lowest pressure to the left, thus blowing from opposite directions when the centre was an area of low or of high pressure.

This was the Cyclonic Theory.

According to this theory, every storm consists of a circular-shaped area of low pressure, round which the wind blew in a direction against watch hands in the Northern Hemisphere, and with watch hands in the Southern one. But here the whole truth had not been arrived at, and many accidents were caused by a sudden chopping of wind, quite at variance with the cyclonic theory.

Now although the greater number of storms are not entirely cyclonic, yet, as a matter of fact, some storms are true cyclones, and are experienced in the West and East Indies, as well as often being found, of small extent, rolling along between two opposing anti-cyclones.

The word anti-cyclone I do not like at all, as the area of high pressure so called is caused by an advancing current which is opposed by another one, as will be seen in the body of the paper. I prefer the term "high pressure area," which does not give any inference beyond assuming that there must be "low pressure" ones, which is true, while the term "anti-cyclone" infers the existence of prevailing "cyclones," while the truth is, that most of our storms are not entirely cyclonic.

Another theory which has been put forward, is the centripetal one. In this, the area of lowest pressure is assumed to be very small, and the winds to blow straight towards this point from all sides, the only modification being due to the earth's revolution. Thus the very large storms which cross the Indian Ocean would have the winds blowing spirally towards the centre, while the smaller tornadoes of North America would not shew this spiral development at all.

Here again the whole truth is not grasped. Spiral winds do blow, but they are not general. In tornadoes the wind, I believe, does blow straight to the centre, but on this point I cannot speak with any degree of certainty.

Another theory is to consider the area of lowest pressure as almost a line, the winds blowing straight towards it from all points. This theory is true only for equatorial winds ; for polar winds it is utterly at fault.

I have tried to set forth in the following paper a theory based upon the siftings of all these theories.

In investigating the question of Storms in South Africa, I have tried all the theories, but find each one unsatisfactory. I have thus, upon due consideration, placed the whole of them on one side, and endeavoured, from actual observation and deduction, to arrive at a true understanding of this question, using the deserted theories as stepping stones to reach the result which I have tried to make clear in the following pages.

THE STORMS OF SOUTH AFRICA.

I wish, before entering into the question of the nature and origin of Storms, to have it distinctly understood what is meant by the term "storm." A storm is nothing more than an atmospheric movement tending to restore a ruptured equilibrium. Every loss of equilibrium, of however slight a nature, generates a storm in the strict sense of the word, although the winds evolved may be only slight. I say advisedly, an atmospheric movement, although I am aware many will disagree with me. They will point out numerous winds blowing, where no storm is, as they assume, notably the trade winds. But I will answer them, that no wind whatever can blow without a disturbance of equilibrium, and that the trade winds blow constantly in one direction because of the existence of a permanent storm along the equator, the so-called belt of calms being in fact the line of constant disturbance.

To understand the nature of storms correctly we must study the distribution of the atmospheric pressure generally over the whole earth. First, let us assume the earth at rest and no disturbing influence whatever at work; what state would the atmosphere be in? The whole atmosphere would be in a state of perfect calm. Now, let us assume the sun to shine vertically over one spot on the earth, what would ensue? In this case the air would rise perpendicularly at that one spot, and a lower current would set in towards it, while a higher one would flow from it, for a limited distance around that spot. And now let us assume that the earth turns on its axis, the sun being vertical over the equator. Here the sun's effect would travel completely round the earth, the result being a belt of rising air, with a lower indraught and upper overflow for a limited distance on either side. We will confine ourselves entirely to the atmospheric movements in the southern hemisphere. Before the upper current had reached the surface of the earth, a great quantity of air would have been drawn from the south towards the equator, the indraw extending almost to the pole. Consequently there would then be a vacancy to fill, and the upper current on reaching the ground would continue its course towards the pole, to fill this vacancy, till meeting the cold banks of high pressure round the pole, it would momentarily force it back; but as the polar pressure increased, this current would in its turn drive the equatorial one back towards the equator, until having penetrated further than necessary to restore equilibrium, a return oscillation would take place and the polar current recede.

We thus see that the atmosphere would be divided into three low pressure belts and four high pressure ones, that is to say,—a low pressure belt round the earth at the equator; two high pressure ones over the north and south tropics; and two low pressure ones in the temperate zones, while two high pressure areas would rest over the poles. Every outburst of solar energy would deepen the equatorial belt, and cause the air to be drawn in greater quantities from either side, while the upper current being intensified would rush over the dense bank of high pressure, and down through the temperate zone to the pole, displacing the polar current, but by that very act giving strength to this polar high pressure area and causing a return oscillation.

Now let us note the effect of the inclination of the earth's axis, whereby the sun appears to travel during six months over a belt of 47 degrees of latitude, that is, from $23\frac{1}{2}°$ N. to $23\frac{1}{2}°$ S. Owing to this apparent motion of the sun, as the disturbed portion is always, in the first instance, where the sun is vertical, the belts of high and low pressure are constantly oscillating north and south, one complete oscillation taking twelve months to perform. Thus, Cape Colony, when the sun is at its southern limit, has the south tropical belt of high pressure to the south of it; but when the sun is at its northern limit, this belt is far to the north of us, and we are on the northern edge of the temperate-zone area of low pressure. Were it not for the unequal distribution of land and sea, the arrangement of atmospheric pressure would be regular, and as sketched above, but as it is, it is far from being so, although on the whole, it is as I have described it, which is near enough for the purpose of investigations where Cape Colony alone is concerned.

By taking the mean barometer readings for different months, and extending over a number of years, isobaric charts have been compiled, and these shew very clearly the distribution of high and low pressure. By referring to one of these for January, it will be seen that a large bank of high pressure lies to the south-west of us, and another to the south-east, being joined together by a col or neck of comparatively lower pressure. The centre line of this area is the limit of the ordinary influence of the equatorial indraw, but when great disturbances take place, the indraw extends further south, and the upper current becomes intensified, bringing violent south-easters over the Colony, and storms in the area of low pressure to the south of us, which after a definite period, return from the south on to the Colony, with north-west winds and rain.

To the north of the Colony, and stretching well to the interior of Africa, is a wild Karoo, hot and dry, called the Kalahari Desert, with extensions to the West Coast and down to Namaqualand. This hot plain plays an important part in our Colonial meteorology. The constant heat generates a constant upward flow of air, and a consequent surrounding circulation. Thus over the Orange Free State and at Kimberley the wind flowing round this area is north or north-east. A portion of the south-east trade flowing from the high pressure area over the South Indian Ocean is deflected and drawn towards this area of low pressure, and intensifies the north wind which flows on to the Colony. How far the geographical distribution of mountains and plains affect this deflection is an open question, but I have no doubt as important a part is played by these in South Africa as in other places.

When any great disturbance takes place at the equator, a strong current sets in off the tropical bank, towards the point of disturbance, and the portion which mingles with the northerly current before-mentioned, increases its intensity considerably, and forces it further on to the Colony. Here it meets the south-east current of the trades, and a semi-cyclonic movement is generated, but as the pressure of the advancing and opposing currents is greater than the lateral pressure, the area of disturbance formed will be of an oval shape, an ellipse in fact, the minor axis being along the point of greatest pressure. Various modifications of this form are experienced when the advancing and opposing currents do not meet at an angle of 180° but at a smaller one.

The north wind, having passed over a tropical portion of the earth, is, as a rule, warmer than the south-east one, consequently it flows up and over the latter, while the south-east wind is deflected and flows more easterly, until reaching the edge of the high pressure area to the south-west of us, the combined forces of the winds increase their power to a very great extent.

So that when an area of low pressure extends across the Colony the winds will flow direct in to it from the north-east, north and north-west, but will flow round it on the south and west sides, as east and south-east winds.

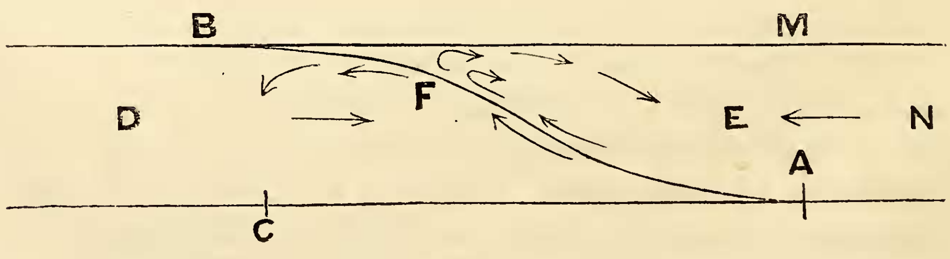
As the power of the north current increases, it forces its way on to the Colony, the area of low pressure thus advancing, until the constant overflow above on to the area supplying the south wind, and its consequent banking up, causes a return oscillation. At the time when the two currents are stationary (which sometimes lasts for days, when the currents are balanced in intensity) the winds blow strongest, and often independent cyclones form in the low pressure area between them and roll off to the east. This I have noticed over and over again. When the south current has gained the victory, it gradually pushes the north one back again, but as this south current generally comes from the south-west, in the form of a high pressure wedge, the elongated area of low pressure over the Colony is split in two, one portion of which recedes to the north, and the other as a cyclone rolls off to the east, bringing storms to Natal and the Eastern Province.

Sometimes the northern current flows right across the Colony, the area of low pressure being driven down to the south-east of us. Then if the south current sets in the two will coalesce, and a very high so-called anti-cyclone be the result. I need scarcely explain that when two currents, flowing in comparatively the same direction, coalesce, the pressure is increased without any cyclonic movement, but when the two currents are opposed, a low pressure area is the result, and often independent cyclones are formed.

When the upper north-west equatorial current is intense it flows down into the area of low pressure to the south of us with great force, and meeting the polar current, drives it back, a storm being the result, the north-west wind blowing straight to the lowest pressure, and the south-east winds being cyclonic. As soon as this current has expended its force, and the polar current becomes banked up and increased in intensity, a return oscillation (as before described) takes place, the distance to which this return storm pushes to the north being proportionate to the intensity of the north-west upper current in the first place. These storms come on to the Colony from the south-west, and even west, and are preceded by easterly and north-easterly winds of no very great intensity. As the area of low pressure advances the wind becomes more northerly, till when the barometer is at its lowest, the wind is generally north-west, but goes round very smartly to the west. This change is usually accompanied by heavy squalls and rain.

To more fully explain the nature of storms, and how they are generated by two opposing currents, I have prepared some diagrams, which I will now refer to.

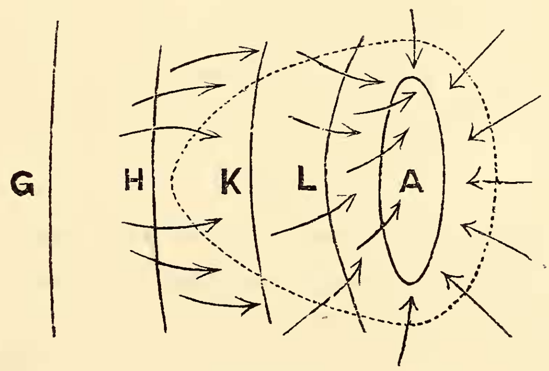
Fig. 1 shews a section through a storm on the plane of the line of motion.



(Fig 1.)

E is the equatorial current and D the polar one. When the two currents come into contact with one another, as E is a rising wind and D a falling one, the rising one will naturally flow up and over the falling one, the line of meeting being shewn at A B. Both cnrrents flow in almost parallel lines at different heights, one having a downward and the other an upward tendency, and wherever either current meets the line A B, the particles of air are carried upwards towards B. At F they reach a point of equilibrium, but being forced upwards by the particles below them, they flow outwards on either side and compensate for the loss sustained by the lower currents.

Now it is evident that if there is an increase of atmosphere at N it will press unduly on D and the whole system will move towards the south. A vacancy will be caused at A, by the upward current from A to B, and the surrounding surface winds will rush in to compensate for the loss, the general direction of the winds being as shewn on Fig. 2.



(Fig. 2.)

Suppose the initial banking up of E (Fig. 1), which caused the motion, to cease ; as the motion is now towards the south, a point would be ultimately reached where the weights at D and N would be balanced.

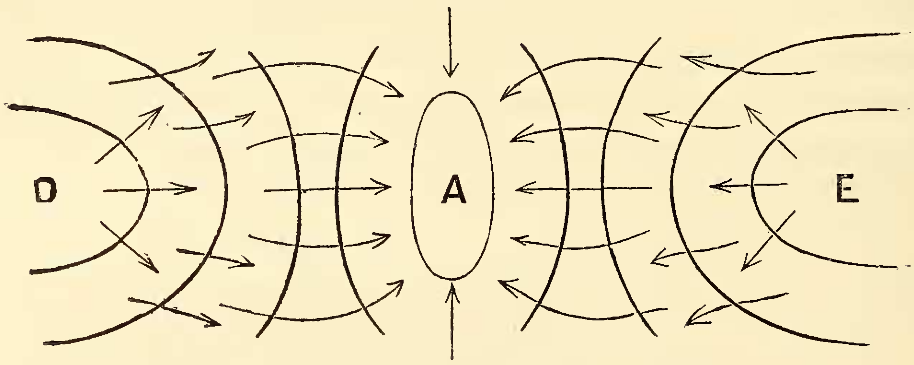
But the depression will not stop here. Dynamic force has to be overcome, and so the disturbance will still travel to the south, till the increased banking up of D will not allow of its further motion, and it will consequently come to a standstill.

But the greatest weight of air being now at D, the whole system will be forced back and be pushed against E in a similar manner, to be in its turn beaten back to D, and so the oscillation will be kept up till equilibrium is restored.

Sometimes the two currents will bank up simultaneously. The depression will then be motionless, but the winds will be very strong and the barometer oscillate violently. Inequalities of surface contour, or patches of intensely heated soil will be enough to generate independent cyclones, which, once formed, will roll along between the two currents and pass away to the east. These little storms are very annoying in upsetting all the pre-arrangements of the forecaster, and very often make him look foolish before the world.

I have observed the two opposing currents remain stationary for a week over the Colony, and cyclone after cyclone roll along the intervening area.

On Fig. 3 I have embraced more of the two currents, and the storm in the form of an isobaric chart.



(Fig. 3.)

E is the equatorial current and D the polar one, A being the area of low pressure at the plane of meeting, close to the surface of the ground. It will be noticed that the winds flow off the areas of high pressure D and E, first in straight lines on all sides, which by the revolution of the earth are gradually deflected in a direction opposite to the motion of the hands of a watch on its face. Were there no disturbing element, these winds would become more and more circular; but coming under the influence of the area of low pressure, they are drawn towards it from all sides. Those of the equatorial current E are seen to blow straight in, and those from the polar one D being deflected round the area in a direction similar to watch hands.

I will now refer to Fig. 1 again.

All atmospheric currents as they travel along contain a certain amount of moisture, although this may be in a state of invisibility. It is a well-known fact that the temperature decreases as we ascend into the atmosphere, and also that if atmosphere containing moisture be carried to an altitude where the temperature is lower than the dew point of its original position, the moisture condenses, and clouds form.

Bearing this in mind it will be noticed that, as the air at A is carried up to B, and contains moisture in an invisible state, this moisture will condense and form clouds at that level. As fresh moist air rushes up, fresh clouds will be formed, each one being larger and more complete than the last, till at A the type will be the large cumulus and cumulo-stratus. As the cloud forming moisture is carried up by the ascending current, a portion will be conveyed back by the return overflow above and being precipitated through the atmosphere at N form various sorts of clouds there. According to the amount of moisture carried up, so will the clouds at N accumulate, and ultimately rain will fall. The direction of the clouds will be parallel to G.H.K.L. on Fig. 2. Those at G will be faint horizontal streaks of cirro-stratus, sometimes barely visible to the eye. Following these at H will come nodules of cirro-cumulus. The pinnacles of these nodules penetrating into the great west upper current above the line B.M. (on Fig. 1) will be blown into thin streaks or threads and form the cirro-filum or thread cirrus. Simultaneous with the dispersion of the upper portions of these nodules, a precipitation will take place into the lower current, the rain being blown towards A on Fig. 1. At K and L (Fig. 2) the clouds will be larger and more perfect in form, till at A, the heavy cumulus, cumulo-stratus and nimbus are formed. Beyond A in the equatorial current, hard rounded cumulus, with intermingled stratus merging into cirro-cumulus and high mottled cirrus will be found. No cirro-stratus will be found on this side of the centre. All along the line A.B. (Fig. 1) the clouds form, and are apt to impinge into the upper current. When this is the case, a precipitation is sure to take place, and if the altitude is not too great, will reach the ground, hence the area of precipitation (shewn by the dotted lines on Fig. 2) is always more on the polar side than on the equatorial one. This is why we have more rain, with our winter storms, after the centre has passed than before.

And now let us study for a few minutes the movements of the barometer during the passing of the system. E (Fig. 1) is a warm current and consequently light, while D is a cold one and of course heavy, but if the whole system is moving towards the south, the intensity of E must be great enough to overcome the weight of D, and consequently the pressure at N must be greater than at D. From C to A the heavier current is gradually becoming less, the current E being much lighter, hence the barometer will gradually fall from

C to A, and as the pressure at N is greater than at D, the barometer will increase from A to N.

Hence whichever way the system is travelling, the barometer will fall till A has passed, but there will be a great difference in the manner of the changes, for while the gradient from C to A is gradual, that from N to A is very abrupt.

So that if with a north-east or north wind, the barometer falls very suddenly, we may almost be certain of rain falling when the barometer begins to rise, especially if heavy cumulus or cumulo-stratus clouds are seen to the south-west, from which direction the following winds will blow.

When a depression is advancing on us from the north-west, the first indication of its approach is a sudden rise of the barometer, and the appearance of long horizontal strips of cirro-stratus to the north-west. These strips follow one another and rise higher and higher. Cirro-filum are often seen before this, in long parallel threads from north to south. When the cirro-stratus has reached the zenith, banks of other and lower cirri come up from the north-west, and the barometer begins to fall, the wind then blowing from the east or south-east. As the depression advances, heavier and lower banks of clouds come up till the whole sky is overcast and rain begins to fall. As soon as the barometer begins to rise, which it does suddenly, rain falls in heavy squalls, and the wind blows strong from the north-west. The storm has passed and fine weather follows.

At Cape Town we very seldom have the centre of such a depression pass over us, but when it does, a black south-easter is followed by showers from the north-west.

In summer time the centre generally passes to the north-east of us, so that the winds are easterly as the centre approaches, south as it passes, and west after it has passed. Rain very seldom falls here, but they are the great rain bringers of the East and Natal.

In winter the centre generally passes to the south-west of us, the wind being then from the north-east as the centre approaches, then north and north-west, and finally west, with rain squalls ending in fine weather.

Some of our severest winter storms are of this type. In these the greatest amount of rain falls before the barometer rises.

The great majority of our winter storms are of a different type. In these the polar current is displacing the equatorial one, hence the sudden manner in which they come upon us. The advance wind of a storm of this type is generally from the north, which changes to the north-west as the centre approaches. As the centre passes, which it does to the south of us, the wind chops round to the west with heavy rain and squalls, which continue as the barometer rises. Fine weather follows with a south-west wind. With these storms the greatest amount of rain falls after the centre has passed.

These depressions bring rain to this end of the Colony during winter and to the other end during summer. Owing to the fact that these storms generally travel alon t he course of the L'Agulhas current, the rain falls in the east with a south wind.

When a depression travels as rapidly as the advance winds blow, a dead calm is very often experienced in front of the storm.

This is very often the case, especially during summer, when the storms come from the north-west.

I have often noticed a gradient between Cape L'Agulhas and Cape Town, which ought to have brought a south-east gale, but only light winds followed, the fact being that the depression, although deep, was travelling as fast towards the east as the advance indraw, in other words it was keeping up with the wind and counteracting its intensity.

I have assumed in all these examples that the two opposing currents are pressing directly against each other ; but such is very seldom the case, they generally abut obliquely and sometimes very much so, and then instead of travelling in the direction of the line of the minor axis of the low pressure area, they travel along a line formed by the resultant of the two opposing currents, and the form of the depression changes from that of an ellipse to almost any shape.

And now before concluding, I should like to say a word or two about sun spots, or rather I should say solar storms. It will be remembered that in a former paper of mine, I laid before you the fact, from actual observation, that upon a sun spot reaching the centre of the sun, various known winds blew at regular intervals thereafter ; thus from two to three days after, a south-easter was sure to blow during the summer months, while eleven days after, north-west or west winds were experienced.

Now the reason of this is shewn in this paper. As soon as the atmosphere at the equator is affected, an upper current rushes towards the poles. It takes two or three days to reach the latitude of Cape Colony, at which date the south wind blows strongly owing to the atmosphere being banked up to the south of us. The upper current then follows the sequence before mentioned and comes upon us eleven days after as a south-west depression.

I have not contiuued my observations on sun spots for the reason that it is impossible for one individual to do everything, and I have found no one interested enough to study this question. Moreover, I do not believe all solar disturbances are visible to us, so that to study this question properly comparison should be made with the observations of magnetical disturbances, which are caused by variations in the sun, and to do this is a study in itself, so that did I devote my spare time to this, I would have to do this alone to the detriment of my other observations, and this I do not care to do.

But if there are any who would like to enter into this investigation, I would suggest the tabulation of magnetical storms, and these I am certain would determine the period of depressions and their nature also. Thus, I have no doubt but that two days after a magnetical storm, a strong north-west upper current flows over Cape Colony, and the barometer banks up to the south, with strong south-east winds. At eleven days after a similar disturbance, a south-west storm of the winter type will come, and so on, regular fixed periods for definite storms. I place the consideration of this question before any one who wishes to further the interests of meteorology.

There is no doubt that electricity plays an important part in our weather. In fact, time may shew that electricity is the one great and sole agent at work, and the sun the great electromotor, the earth being the accumulator.

I do not know whether any present have noticed the manner in which cumulus clouds group, but I have, often. As far as my observations have extended at the Cape, they seem to aggregate in horizontal banks of a definite width and parallel to each other, the line of stratification being along the magnetic meridians. I do not bring forward any reason to account for this, but merely give it as an authenticated observation, leaving it for the future to decide what the meaning may be.

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Cape Town,
30th March, 1887.